WHAT FLAT PANELS LACK WHEN IT COMES TO PERFORMANCE

Technical comparisons of flat-panel and microwave-dish antennas reveal substantial differences in forward gain and side lobes. Also, the diminishing returns of increasing array size with flat panels can be traced to the substrate commonly used.

By Andy Singer

My subject probably is obvious from the title. Many original equipment manufacturers (OEMs) of 802.11 and 802.16-type radios have been promoting flat-panel antennas for use with their radios. The following information is intended to demonstrate that performance of these flat-panel antennas at microwave frequencies is poor. The gain and patterns of flat-panel antennas are inferior to parabolic-dish antennas at microwave frequencies.

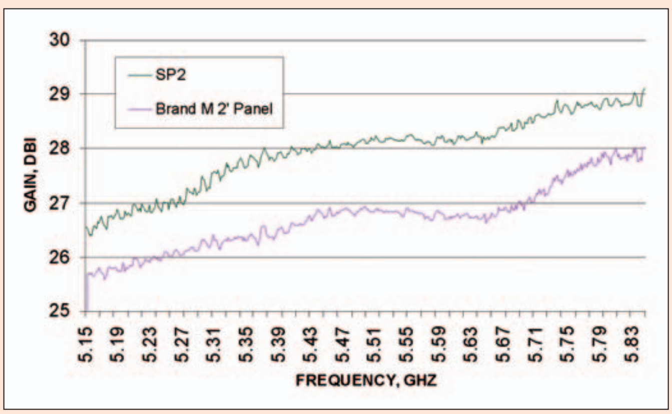

Figure 1. The gain of a microwave dish is compared with the gain of a flat panel, revealing about 1.5 decibels of higher gain in favor of the dish.

Unlicensed radios

The market for unlicensed radios grew during the past decade and became large because of the relatively low cost of these solutions and the lack of a licensing requirement. However, because of the unlicensed nature of these radios for bands such as 5 GHz, it is critical that the antenna provides as much gain as possible in the desired direction along with superior side-lobe performance to minimize the probability of transmitting or receiving interference from other users in the area in directions off of boresight. As the spectrum continues to get more crowded with users, it becomes even more important to preserve spectrum by using antennas with the best possible pattern performance.

Over the last couple of years, I have noticed OEMs for 802.11 and 802.16 radios using flat panels more frequently. If you ask them why, they will state that it is because of the flat-panel antenna's low profile and excellent performance. I have been either designing or marketing antennas since I graduated from engineering school in 1986, and the claims of good performance relative to parabolic-dish antennas just did not make sense to me. At Radio Waves, we decided to purchase a couple of brand-X flat-panel antenna arrays that many OEMs use and perform a side-by-side comparison of our SP2-5.2 2-foot parabolic dish and the 2-foot flat-panel antenna. We wanted documented data showing foot-for-foot which type of antenna has better performance.

The gain testing was straightforward. We placed two antennas on the antenna range and measured gain across the unlicensed 5-GHz band from 5.15 GHz to 5.85 GHz against a standard to determine each antenna's gain. The SP2-5.2 parabolic dish exhibited about 1.5 decibels higher gain than the flat-panel antenna. (See Figure 1). The reason the parabolic-dish antenna has higher gain is because at microwave frequencies, the parabolic dish is inherently a more efficient design. By efficiency, we mean more of the power that is fed into the antenna is radiated than with the flat-panel antenna. The flat-panel array is etched on a printed circuit (PC) board substrate, and each of the many elements of the flat panel array must be fed with a transmission line etched on the PC board. The use of many transmission lines results in a large amount of distributed losses. Even if the manufacturer selects a decent-quality material for the PC board substrate, there are significant distributed losses as the RF energy travels through the PC board. Thus, the parabolic dish is more efficient and, in this case, the difference was about 1.5 decibels higher gain for the SP2-5.2 dish antenna than the equivalent-sized flat-panel antenna.

Testing at 5 GHz

Another point to keep in mind is that testing was done at 5 GHz. If you were to use a flat-panel antenna at higher microwave frequencies, the losses in the PC board substrate would only worsen and the gain loss relative to a parabolic dish would worsen. For instance, with a 2-foot panel at 18 GHz, these losses would be on the order of several decibels. Up until a couple of years ago, at least one OEM radio manufacturer sold a 1-foot flat-panel antenna for use with its licensed 38-GHz radios. We managed to acquire one of these 38-GHz flat-panel antennas, and its measured gain was below its advertised gain. This 38-GHz flat panel is, perhaps not surprisingly, not offered for sale any more. Methods exist to overcome these losses, such as using active devices on the array itself, but their complexity makes them cost-prohibitive for commercial applications. Using such methods would require a panel antenna to be priced in an order of magnitude higher, at about $1,000 per unit.

Another way to view this issue of distributed losses with flat-panel antenna PC-board arrays is that as the number of elements in the array increases, the corresponding increase in gain is less as the size of the array increases. Let me repeat that. As the number of elements in the array increases, the gain increase becomes smaller. This is what is known as a diminishing-return curve. The graphic representation of the diminishing-return curve would show array size on a horizontal axis and gain as the vertical axis. Depending on the specific substrate selected for the PC board material, after an array of about 16 x 16 elements is placed upon it, the transmission line losses become so high that the antenna's gain actually flattens and then decreases as more elements are added. That is why you don't see large flat-panel arrays available at microwave frequencies. As noted before, the flat-panel antennas simply do not have anywhere near the efficiency of a parabolic dish. Not only does this become increasingly evident at higher frequencies, it becomes increasingly evident as the size of the antenna increases.

Next, we measured patterns of the two antennas and graphed them in rectangular coordinates. A copy of the pattern measurements can be seen in Figure 2. The radiation pattern of the SP2-5.2 is substantially better than the brand-X flat-panel antenna. The first side lobe of the parabolic dish is actually a whopping 15 decibels lower than with the flat panel antenna. The rest of the side lobes, on average, are about 10 decibels lower with the parabolic dish. Because the side lobes are so dramatically better with the parabolic dish, it would be far superior to a flat panel in avoiding interference and preserving spectrum in today's crowded bands.

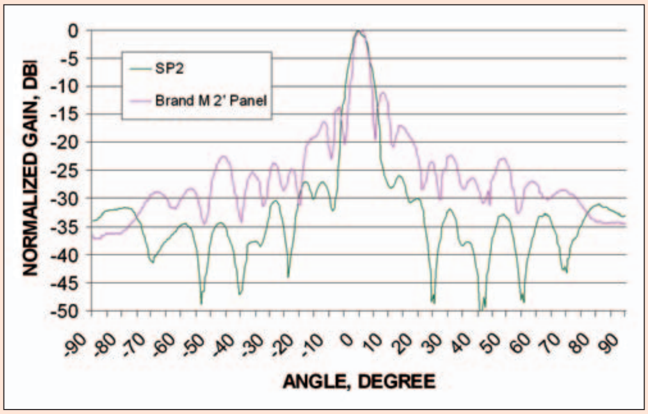

Figure 2. The radiation pattern of a microwave dish is compared with the pattern of a flat panel, revealing higher unwanted side lobes with the panel antenna.

Low profile

This leads to the next question, why do radio OEMs use flat panel antennas? The choice is not made based on performance because both the gain and the patterns are inferior to those of a parabolic-dish antenna of the same size. At Radio Waves, we manufacture flat-panel antennas to use where a low-profile look is required, but we are open with customers about the fact that flat-panel antenna performance is not as good as a dish antenna. In some cases, I am sure the OEM recommends the flat-panel antennas because of the need for a low-profile antenna even at the risk of lower performance, but in many cases users require the best possible link performance and best possible protection from interference, yet the flat panel cannot provide them. The reason seems apparent; in many cases, OEMs promote the use of a flat panel simply as a matter of profit. The producer of these flat panels used by the OEMs builds them with low-cost materials and labor in India or China and then sells them to the OEMs in volume for a very low price. The OEM can then mark the antenna up to a much higher price and make an excellent margin on the flat-panel antenna sale.

If you are looking for the best gain and pattern to optimize network performance and protect your link from interference, a parabolic dish will always provide better performance than the same size flat-panel antenna. **agl**

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